CHAPTER 15 (Odd)

1. a. $R \angle 0° = \mathbf{6.8\ \Omega\ \angle 0° = 6.8\ \Omega}$

   b. $X_L = \omega L = (377 \text{ rad/s})(2 \text{ H}) = 754\ \Omega$
   $X_L \angle 90° = \mathbf{754\ \Omega\ \angle 90° = +j754\ \Omega}$

   c. $X_L = 2\pi fL = (6.28)(50 \text{ Hz})(0.05 \text{ H}) = 15.7\ \Omega$
   $X_L \angle 90° = \mathbf{15.7\ \Omega\ \angle 90° = +j15.7\ \Omega}$

   d. $X_C = \dfrac{1}{\omega C} = \dfrac{1}{(377 \text{ rad/s})(10 \times 10^{-6} \text{ F})} = 265.25\ \Omega$
   $X_C \angle -90° = \mathbf{265.25\ \Omega\ \angle -90° = -j265.25\ \Omega}$

   e. $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(10 \times 10^3 \text{ Hz})(0.05 \times 10^{-6} \text{ F})} = 318.47\ \Omega$
   $X_C \angle -90° = \mathbf{318.47\ \Omega\ \angle -90° = -j318.47\ \Omega}$

   f. $R \angle 0° = 200\ \Omega\ \angle 0° = 200\ \Omega$

3. a. $\mathbf{I} = (0.707)(4 \text{ mA} \angle 0°) = 2.828 \text{ mA} \angle 0°$
   $\mathbf{V} = (I \angle 0°)(R \angle 0°) = (2.828 \text{ mA} \angle 0°)(22\ \Omega \angle 0°) = 62.216 \text{ mV} \angle 0°$
   $v = \mathbf{88 \times 10^{-3} \sin \omega t}$

   b. $\mathbf{I} = (0.707)(1.5 \text{ A} \angle 60°) = 1.0605 \text{ A} \angle 60°$
   $X_L = \omega L = (377 \text{ rad/s})(0.016 \text{ H}) = 6.032\ \Omega$

   $\mathbf{V} = (I \angle \theta)(X_L \angle 90°) = (1.0605 \text{ A} \angle 60°)(6.032\ \Omega \angle 90°) = 6.397 \text{ V} \angle 150°$
   $v = \mathbf{9.045 \sin(377t + 150°)}$

   c. $\mathbf{I} = (0.707)(20 \text{ mA} \angle 40°) = 14.14 \text{ mA} \angle 40°$
   $X_C = \dfrac{1}{\omega C} = \dfrac{1}{(157 \text{ rad/s})(0.05 \times 10^{-6} \text{ F})} = 127.39 \text{ k}\Omega$

   $\mathbf{V} = (I \angle \theta)(X_C \angle -90°) = (14.14 \text{ mA} \angle 40°)(127.39 \text{ k}\Omega \angle -90°)$
   $= 1801.3 \text{ V} \angle -50°$
   $V_p = \sqrt{2}(1801.3 \text{ V}) = 2547.4 \text{ V}$
   and $v = \mathbf{2547.4 \sin(157t - 50°)}$

5. a. $\mathbf{Z}_T = 3\ \Omega + j4\ \Omega - j7\ \Omega = \mathbf{3\ \Omega - j3\ \Omega = 4.24\ \Omega \angle -45°}$

   b. $\mathbf{Z}_T = 0.5 \text{ k}\Omega + j7 \text{ k}\Omega - j4 \text{ k}\Omega = \mathbf{0.5 \text{ k}\Omega + j3 \text{ k}\Omega = 3.04 \text{ k}\Omega \angle 80.54°}$

   c. $L_T = 0.26 \text{ H} = 260 \times 10^{-3} \text{ H} = 260 \text{ mH}$
   $X_L = \omega L = 2\pi fL = 2\pi(10^3 \text{ Hz})(260 \times 10^{-3} \text{ H}) = 1632.8\ \Omega$
   $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(10^3 \text{ Hz})(10 \times 10^{-6} \text{ F})} = 15.92\ \Omega$
   $\mathbf{Z}_T = 47\ \Omega + j1632.8\ \Omega - j15.92\ \Omega$
   $= \mathbf{47\ \Omega + j1616.88\ \Omega = 1617.56\ \Omega \angle 88.33°}$

7. a. $\mathbf{Z}_T = 8\ \Omega + j6\ \Omega = \mathbf{10\ \Omega\ \angle 36.87^\circ}$

c. $\mathbf{I} = \mathbf{E}/\mathbf{Z}_T = 100\text{ V}\ \angle 0^\circ/10\ \Omega\ \angle 36.87^\circ = \mathbf{10\ A\ \angle -36.87^\circ}$
$\mathbf{V}_R = (I\ \angle\theta)(R\ \angle 0^\circ) = (10\text{ A}\ \angle -36.87^\circ)(8\ \Omega\ \angle 0^\circ) = \mathbf{80\ V\ \angle -36.87^\circ}$
$\mathbf{V}_L = (I\ \angle\theta)(X_L\ \angle 90^\circ) = (10\text{ A}\ \angle -36.87^\circ)(6\ \Omega\ \angle 90^\circ) = \mathbf{60\ V\ \angle 53.13^\circ}$

f. $P = I^2R = (10\text{ A})^2\ 8\ \Omega = \mathbf{800\ W}$

g. $F_p = \cos\theta_T = R/Z_T = 8\ \Omega/10\ \Omega = \mathbf{0.8\ lagging}$

9. a. $X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(10^3\text{ Hz})(0.1\times 10^{-6}\text{ F})} = 1592.36\ \Omega$

$\mathbf{Z}_T = 470\ \Omega - j1592.36\ \Omega = \mathbf{1660.27\ \Omega\ \angle -73.56^\circ}$

b. $\mathbf{I} = \mathbf{E}/\mathbf{Z}_T = 14.14\text{ V}\ \angle 0^\circ/1660.27\ \Omega\ \angle -73.56^\circ = \mathbf{8.517\ mA\ \angle 73.56^\circ}$

c. $\mathbf{V}_R = (I\ \angle\theta)(R\ \angle 0^\circ) = (8.517\text{ mA}\ \angle 73.56^\circ)(0.470\times 10^3\ \Omega\ \angle 0^\circ) = \mathbf{4\ V\ \angle 73.56^\circ}$
$\mathbf{V}_L = (I\ \angle\theta)(X_C\ \angle -90^\circ) = (8.517\text{ mA}\ \angle 73.56^\circ)(1592.36\ \Omega\ \angle -90^\circ)$
$= \mathbf{13.562\ V\ \angle -16.44^\circ}$

d. $P = I^2R = (8.517\text{ mA})^2\ 470\ \Omega = \mathbf{34.09\ mW}$
$F_p = \cos\theta_T = \cos 73.56^\circ = \mathbf{0.283\ leading}$

11. a. $\mathbf{Z}_T = 3\text{ k}\Omega + j2\text{ k}\Omega - j1\text{ k}\Omega = 3\text{ k}\Omega + j1\text{ k}\Omega = \mathbf{3.16\ k\Omega\ \angle 18.43^\circ}$

c. $X_C = \dfrac{1}{\omega C} \Rightarrow C = \dfrac{1}{\omega X_C} = \dfrac{1}{(314\text{ rad/s})(10^3\ \Omega)} = \mathbf{3.18\ \mu F}$

$X_L = \omega L \Rightarrow L = \dfrac{X_L}{\omega} = \dfrac{2\times 10^3\ \Omega}{314\text{ rad/s}} = \mathbf{6.37\ H}$

d. $\mathbf{I} = \mathbf{E}/\mathbf{Z}_T = 4.242\text{ V}\ \angle 60^\circ/3.16\text{ k}\Omega\ \angle 18.43^\circ = \mathbf{1.3424\ mA\ \angle 41.57^\circ}$
$\mathbf{V}_R = (I\ \angle\theta)(R\ \angle 0^\circ) = (1.3424\text{ mA}\ \angle 41.57^\circ)(3\text{ k}\Omega\ \angle 0^\circ) = \mathbf{4.027\ V\ \angle 41.57^\circ}$
$\mathbf{V}_L = (I\ \angle\theta)(X_L\ \angle 90^\circ) = (1.3424\text{ mA}\ \angle 41.57^\circ)(2\text{ k}\Omega\ \angle 90^\circ) = \mathbf{2.6848\ V\ \angle 131.57^\circ}$
$\mathbf{V}_C = (I\ \angle\theta)(X_C\ \angle -90^\circ) = (1.3424\text{ mA}\ \angle 41.57^\circ)(1\text{ k}\Omega\ \angle -90^\circ)$
$= \mathbf{1.3424\ V\ \angle -48.43^\circ}$

g. $P = I^2R = (1.3424\text{ mA})^2\ 3\text{ k}\Omega = \mathbf{5.406\ mW}$

h. $F_p = \cos\theta_T = \cos 18.43^\circ = \mathbf{0.9487\ lagging}$

i. $i = \mathbf{1.898\times 10^{-3}\sin(\omega t + 41.57^\circ)}$
$v_R = \mathbf{5.6942\sin(\omega t + 41.57^\circ)}$
$v_L = \mathbf{3.7963\sin(\omega t + 131.57^\circ)}$
$v_C = \mathbf{1.8982\sin(\omega t - 48.43^\circ)}$

13. a. $V_L(\text{rms}) = 0.7071\left[\frac{21.28\text{ V}}{2}\right] = 7.524\text{ V}$

$$X_L = \frac{V_L}{I_L} = \frac{7.524\text{ V}}{29.94\text{ mA}} = 251.303\ \Omega$$

$$X_L = 2\pi fL \Rightarrow L = \frac{X_L}{2\pi f} = \frac{251.303\ \Omega}{2\pi(1\text{ kHz})} = 39.996\text{ mH} \cong \mathbf{40\text{ mH}}$$

b.

E, 10 V, V_L, 7.524 V, I, V_R

$$E^2 = V_R^2 + V_L^2$$

$$V_R = \sqrt{E^2 - V_L^2}$$

$$= \sqrt{(100\text{ V}) - (56.611)} = \sqrt{43.389} = 6.587\text{ V}$$

$$R = \frac{V_R}{I_R} = \frac{6.587\text{ V}}{29.94\text{ mA}} = \mathbf{220\ \Omega}$$

15. a. $\mathbf{V}_1 = \frac{(2\text{ k}\Omega\ \angle 0°)(120\text{ V}\ \angle 20°)}{2\text{ k}\Omega + j6\text{ k}\Omega} = \frac{240\text{ V}\ \angle 20°}{6.32\ \angle 71.57°} = \mathbf{37.97\text{ V}\ \angle -51.57°}$

$$\mathbf{V}_2 = \frac{(6\text{ k}\Omega\ \angle 90°)(120\text{ V}\ \angle 20°)}{6.32\text{ k}\Omega\ \angle 71.57°} = \mathbf{113.92\text{ V}\ \angle 38.43°}$$

b. $\mathbf{V}_1 = \frac{(40\text{ k}\Omega\ \angle 90°)(60\text{ V}\ \angle 5°)}{6.8\ \Omega + j40\ \Omega + 9\ \Omega} = \frac{2400\text{ V}\ \angle 95°}{15.8 + j40} = \mathbf{55.80\ \angle 26.55°}$

$$\mathbf{V}_2 = \frac{(9\ \Omega\ \angle 0°)(60\text{ V}\ \angle 5°)}{43.01\ \Omega\ \angle 68.45°} = \frac{540\ V\ \angle 5°}{43.01\ \angle 68.45°} = \mathbf{12.56\text{ V}\ \angle -63.45°}$$

17. a. $X_L = \omega L = (377\text{ rad/s})(0.4\text{ H}) = 150.8\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{(377\text{ rad/s})(4\ \mu\text{F})} = 663\ \Omega$$

$$\mathbf{Z}_T = 30\ \Omega + j150.8\ \Omega - j663\ \Omega = 30\ \Omega - j512.2\ \Omega = \mathbf{513.08\ \Omega\ \angle -86.65°}$$

$$\mathbf{I} = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{20\text{ V}\ \angle 40°}{513.08\ \Omega\ \angle -86.65°} = \mathbf{39\text{ mA}\ \angle 126.65°}$$

$$\mathbf{V}_R = (I\ \angle\theta)(R\ \angle 0°) = (39\text{ mA}\ \angle 126.65°)(30\ \Omega\ \angle 0°) = \mathbf{1.17\text{ V}\ \angle 126.65°}$$

$$\mathbf{V}_C = (39\text{ mA}\ \angle 126.65°)(0.663\text{ k}\Omega\ \angle -90°) = \mathbf{25.86\text{ V}\ \angle 36.65°}$$

b. $\cos\theta_T = \frac{R}{Z_T} = \frac{30\ \Omega}{513.08\ \Omega} = \mathbf{0.058\text{ leading}}$

c. $P = I^2R = (39\text{ mA})^2\ 30\ \Omega = \mathbf{45.63\text{ mW}}$

f. $\mathbf{V}_R = \frac{(30\ \Omega\ \angle 0°)(20\text{ V}\ \angle 40°)}{\mathbf{Z}_T} = \frac{600\text{ V}\ \angle 40°}{513.08\ \angle -86.65°} = \mathbf{1.17\text{ V}\ \angle 126.65°}$

$$\mathbf{V}_C = \frac{(0.663\text{ k}\Omega\ \angle -90°)(20\text{ V}\ \angle 40°)}{513.08\ \Omega\ \angle -86.65°} = \mathbf{25.84\text{ V}\ \angle 36.65°}$$

g. $\mathbf{Z}_T = \mathbf{30\ \Omega - j512.2\ \Omega} = R - jX_C$

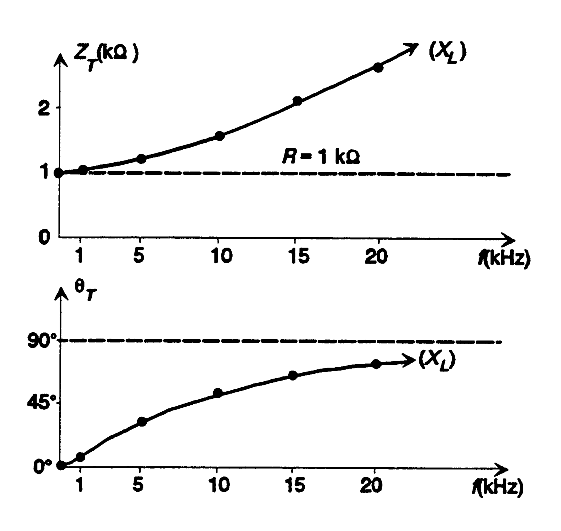
19. $P = VI\cos\theta \Rightarrow 8000\text{ W} = (200\text{ V})(I)(0.8)$

$$I = \frac{8000\text{ A}}{160} = 50\text{ A}$$

$$0.8 = \cos\theta$$
$$\theta = 36.87°$$
$$\mathbf{V} = 200\text{ V}\angle 0°, I = 50\text{ A}\angle -36.87°$$
$$\mathbf{Z}_T = \frac{\mathbf{V}}{\mathbf{I}} = \frac{200\text{ V}\angle 0°}{50\text{ A}\angle -36.87°} = 4\ \Omega\angle 36.87° = \mathbf{3.2\ \Omega + j2.4\ \Omega}$$

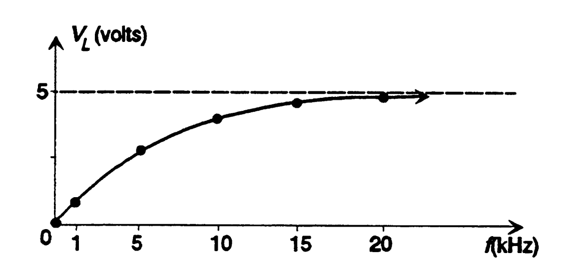
21. a. $\mathbf{Z}_T = \sqrt{R^2 + X_L^2}\angle\tan^{-1}X_L/R$

f	Z_T	θ_T
0 Hz	1.0 kΩ	0.0°
1 kHz	1.008 kΩ	7.16°
5 kHz	1.181 kΩ	32.14°
10 kHz	1.606 kΩ	51.49°
15 kHz	2.134 kΩ	62.05°
20 kHz	2.705 kΩ	68.3°



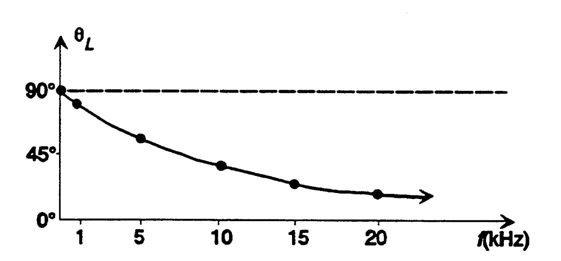
b. $V_L = \frac{X_L E}{Z_T}$

f	V_L
0 Hz	0.0 V
1 kHz	0.623 V
5 kHz	2.66 V
10 kHz	3.888 V
15 kHz	4.416 V
20 kHz	4.646 V



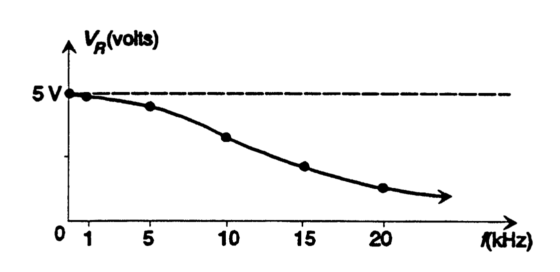
c.

f	$\theta_L = 90° - \tan^{-1}X_L/R$
0 Hz	90.0°
1 kHz	82.84°
5 kHz	57.85°
10 kHz	38.5°
15 kHz	27.96°
20 kHz	21.7°



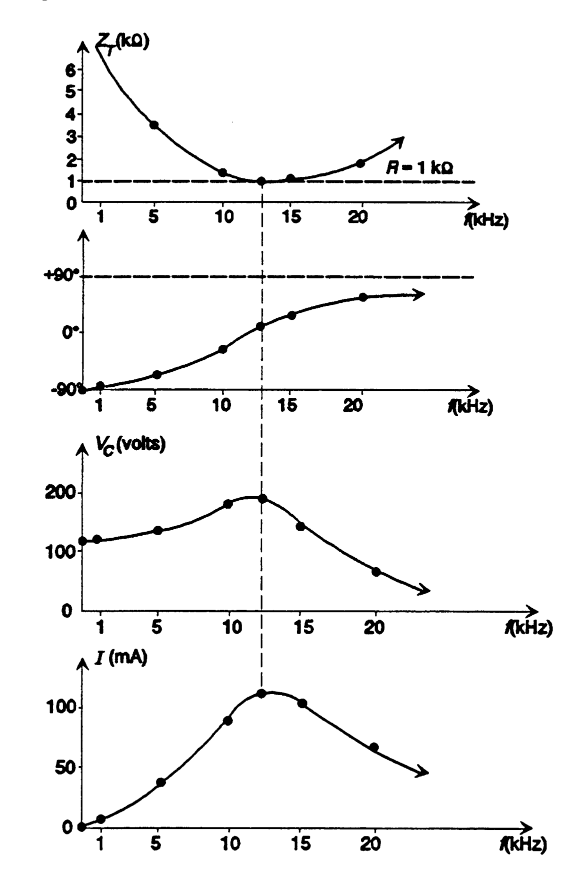
d.

f	$V_R = RE/Z_T$
0 Hz	5.0 V
1 kHz	4.96 V
5 kHz	4.23 V
10 kHz	3.11 V
15 kHz	2.34 V
20 kHz	1.848 V



23. a. $\mathbf{Z}_T = \sqrt{R^2 + (X_L - X_C)^2} \angle \tan^{-1}(X_L - X_C)/R$

f	Z_T	θ_T
0 Hz	∞ Ω	−90.0°
1 kHz	19,793.97 Ω	−87.1°
5 kHz	3,496.6 Ω	−73.38°
10 kHz	1,239.76 Ω	−36.23°
15 kHz	1,145.47 Ω	+29.19°
20 kHz	1,818.24 Ω	+56.63°



b. $|V_C| = \dfrac{X_C E}{Z_T}$

f	$\lvert V_C \rvert$
0 Hz	120.0 V
1 kHz	120.61 V
5 kHz	136.55 V
10 kHz	192.57 V
15 kHz	138.94 V
20 kHz	65.65 V

c. $|I| = \dfrac{E}{Z_T}$

f	I
0 Hz	0.0 mA
1 kHz	6.062 mA
5 kHz	34.32 mA
10 kHz	96.79 mA
15 kHz	104.76 mA
20 kHz	66.0 mA

25. a. $\mathbf{Z}_T = 3\ \Omega + j8\ \Omega = \mathbf{8.544\ \Omega \angle 69.44°}$, $\mathbf{Y}_T = \mathbf{0.117\ S \angle -69.44}$

$\mathbf{Y}_T = \mathbf{41.1\ mS} - \mathbf{j109.5\ mS} = G - jB_L$

b. $\mathbf{Z}_T = 40\ \Omega + 20\ \Omega - j70\ \Omega = \mathbf{60\ \Omega - j70\ \Omega = 92.195\ \Omega\ \angle -49.40^\circ}$

$\mathbf{Y}_T = \mathbf{10.9\ mS\ \angle 49.40^\circ = 7.1\ mS + j8.3\ mS} = G + jB_C$

c. $\mathbf{Z}_T = 200\ \Omega + j500\ \Omega - j600\ \Omega = \mathbf{200\ \Omega - j100\ \Omega = 223.61\ \Omega\ \angle -26.57^\circ}$

$\mathbf{Y}_T = \mathbf{4.47\ mS\ \angle 26.57^\circ = 4\ mS + j2\ mS} = G + jB_C$

27. a. $\mathbf{Y}_T = \dfrac{1}{2\ \Omega\ \angle 0^\circ} + \dfrac{1}{5\ \Omega\ \angle 90^\circ} = 0.5\text{ S} - j0.2\text{ S} = \mathbf{538.52\ mS\ \angle -21.8^\circ}$

c. $\mathbf{E} = \mathbf{I}_s/\mathbf{Y}_T = 2\text{ A}\ \angle 0^\circ/0.539\text{ S}\ \angle -21.8^\circ = \mathbf{3.71\ V\ \angle 21.8^\circ}$

$\mathbf{I}_R = \dfrac{E\ \angle\theta}{R\ \angle 0^\circ} = 3.71\text{ V}\ \angle 21.8^\circ/2\ \Omega\ \angle 0^\circ = \mathbf{1.855\ A\ \angle 21.8^\circ}$

$\mathbf{I}_L = \dfrac{E\ \angle\theta}{X_L\ \angle 90^\circ} = 3.71\text{ V}\ \angle 21.8^\circ/5\ \Omega\ \angle 90^\circ = \mathbf{0.742\ A\ \angle -68.2^\circ}$

f. $P = I^2R = (1.855\text{ A})^2\ 2\ \Omega = \mathbf{6.88\ W}$

g. $F_p = \dfrac{G}{Y_T} = \dfrac{0.5\ S}{0.539\ S} = \mathbf{0.928\ lagging}$

h. $e = \mathbf{5.25\ sin(377\mathit{t} + 21.8^\circ)}$
$i_R = \mathbf{2.62\ sin(377\mathit{t} + 21.8^\circ)}$
$i_L = \mathbf{1.049\ sin(377\mathit{t} - 68.2^\circ)}$
$i_s = \mathbf{2.828\ sin\ 377\mathit{t}}$

29. a. $\mathbf{Y}_T = \dfrac{1}{12\ \Omega\ \angle 0^\circ} + \dfrac{1}{10\ \Omega\ \angle 90^\circ} = 0.083\text{ S} - j0.1\text{ S} = \mathbf{129.96\ mS\ \angle -50.31^\circ}$

c. $\mathbf{I}_s = \mathbf{E}\mathbf{Y}_T = (60\text{ V}\ \angle 0^\circ)(0.13\text{ S}\angle -50.31^\circ) = \mathbf{7.8\ A\ \angle -50.31^\circ}$

$\mathbf{I}_R = \dfrac{E\ \angle\theta}{R\ \angle\ 0^\circ} = 60\text{ V}\ \angle 0^\circ/12\ \Omega\ \angle 0^\circ = \mathbf{5\ A}\ \angle 0^\circ$

$\mathbf{I}_L = \dfrac{E\ \angle\theta}{X_L\ \angle\ 90^\circ} = 60\text{ V}\ \angle 0^\circ/10\ \Omega\ \angle 90^\circ = \mathbf{6\ A\ \angle -90^\circ}$

f. $P = I^2R = (5\text{ A})^2\ 12\ \Omega = \mathbf{300\ W}$

g. $F_p = G/Y_T = 0.083\text{ S}/0.13\text{ S} = \mathbf{0.638\ lagging}$

h. $e = \mathbf{84.84\ sin\ 377\mathit{t}}$
$i_R = \mathbf{7.07\ sin\ 377\mathit{t}}$
$i_L = \mathbf{8.484\ sin(377\mathit{t} - 90^\circ)}$
$i_s = \mathbf{11.03\ sin(377\mathit{t} - 50.31^\circ)}$

31. a. $\mathbf{Y}_T = \dfrac{1}{3\text{ k}\Omega\ \angle 0^\circ} + \dfrac{1}{4\text{ k}\Omega\ \angle 90^\circ} + \dfrac{1}{2\text{ k}\Omega\ \angle -90^\circ}$
$= 0.333\text{ mS}\ \angle 0^\circ + 0.25\text{ mS}\ \angle -90^\circ + 0.5\text{ mS}\ \angle 90^\circ$
$= \mathbf{0.333\ mS + j0.25\ mS = 0.416\ mS\ \angle 36.897^\circ}$

c. $X_L = \omega L \Rightarrow L = X_L/\omega = 4000\ \Omega/377\ \text{rad/s} = \mathbf{10.61\ H}$

$$X_C = \frac{1}{\omega C} \Rightarrow C = \frac{1}{\omega X_C} = \frac{1}{(377\ \text{rad/s})(2000\ \Omega)} = \mathbf{1.326\ \mu F}$$

d. $\mathbf{E} = \mathbf{I}/\mathbf{Y}_T = 3.535\ \text{mA}\ \angle -20°/0.416\ \text{mS}\ \angle 36.897° = \mathbf{8.498\ V\ \angle -56.897°}$

$$\mathbf{I}_R = \frac{E\ \angle\theta}{R\ \angle 0°} = 8.498\ \text{V} \angle -56.897°/3\ \text{k}\Omega\ \angle 0° = \mathbf{2.833\ mA\ \angle -56.897°}$$

$$\mathbf{I}_L = \frac{E\ \angle\theta}{X_L\ \angle 90°} = 8.498\ \text{V} \angle -56.897°/4\ \text{k}\Omega\ \angle 90° = \mathbf{2.125\ mA\ \angle -146.897°}$$

$$\mathbf{I}_C = \frac{E\ \angle\theta}{X_C\ \angle -90°} = 8.498\ \text{V} \angle -56.897°/2\ \text{k}\Omega\ \angle -90° = \mathbf{4.249\ mA\ \angle 33.103°}$$

g. $P = I^2R = (2.833\ \text{mA})^2 \cdot 3\ \text{k}\Omega = \mathbf{24.078\ mW}$

h. $F_p = G/Y_T = 0.333\ \text{mS}/0.416\ \text{mS} = \mathbf{0.8\ leading}$

i. $e = \mathbf{12.016 \sin(377t - 56.897°)}$
$i_R \cong \mathbf{4 \sin(377t - 56.897°)}$
$i_L \cong \mathbf{3 \sin(377t - 146.897°)}$
$i_C = \mathbf{6 \sin(377t + 33.103°)}$

33. a. $$\mathbf{I}_1 = \frac{(70\ \Omega\ \angle 90°)(20\ \text{A}\ \angle 40°)}{33\ \Omega + j70\ \Omega} = \frac{1400\ \text{A}\ \angle 130°}{77.389\ \angle 64.759°} = \mathbf{18.09\ A\ \angle 65.241°}$$

$$\mathbf{I}_2 = \frac{(33\ \Omega\ \angle 0°)(20\ \text{A}\ \angle 40°)}{77.389\ \angle 64.759°} = \frac{660\ \text{A}\ \angle 40°}{77.389\ \angle 64.759°} = \mathbf{8.528\ A\ \angle -24.759°}$$

b. $$\mathbf{I}_1 = \frac{(3\ \Omega - j6\ \Omega)(6\ \text{A}\ \angle 30°)}{3\ \Omega - j6\ \Omega + j4\ \Omega} = \frac{(6.708\ \angle -63.435°)(6\ \text{A}\ \angle 30°)}{3 - j2}$$

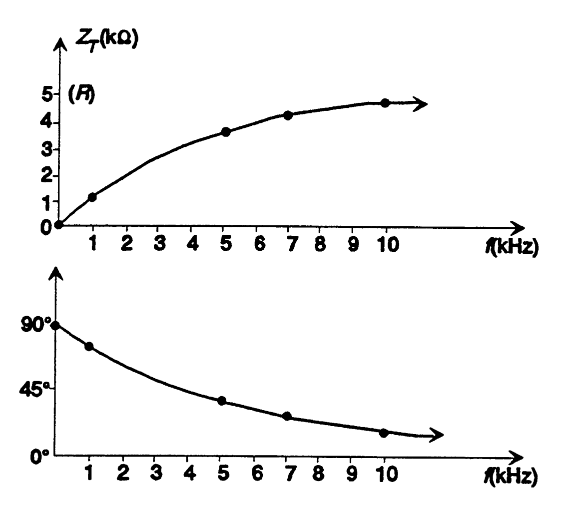
$$= \frac{40.248\ \text{A}\ \angle -33.435°}{3.606\ \angle -33.690°} = \mathbf{11.161\ A\ \angle 0.255°}$$

$$\mathbf{I}_2 = \frac{(4\ \Omega\ \angle 90°)(6\ \text{A}\ \angle 30°)}{3.606\ \Omega \angle -33.690°} = \frac{24\ \text{A}\ \angle 120°}{3.606\ \angle -33.690°} = \mathbf{6.656\ A\ \angle 153.690°}$$

35. a. $\mathbf{Z}_T = \dfrac{\mathbf{Z}_R\mathbf{Z}_L}{\mathbf{Z}_R + \mathbf{Z}_L} = \dfrac{(R\ \angle 0°)(X_L\ \angle 90°)}{R + jX_L} = \dfrac{RX_L}{\sqrt{R^2 + X_L^2}} \angle 90° - \tan^{-1}X_L/R$

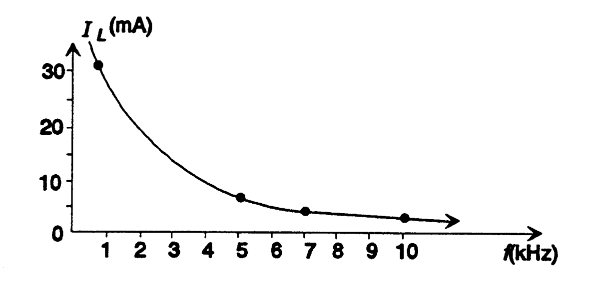
$|Z_T| = \dfrac{RX_L}{\sqrt{R^2 + X_L^2}}$ $\theta_T = 90° - \tan^{-1}X_L/R$

f	$\lvert \mathbf{Z}_T \rvert$	θ_T
0 Hz	0.0 kΩ	90.0°
1 kHz	1.22 kΩ	75.86°
5 kHz	3.91 kΩ	38.53°
7 kHz	4.35 kΩ	29.6°
10 kHz	4.65 kΩ	21.69°

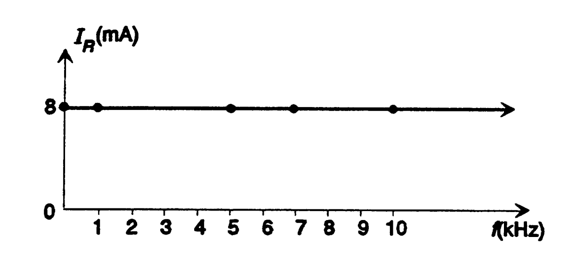


b. $|I_L| = \dfrac{E}{X_L}$

f	$\lvert I_L \rvert$
0 Hz	∞
1 kHz	31.75 mA
5 kHz	6.37 mA
7 kHz	4.55 mA
10 kHz	3.18 mA

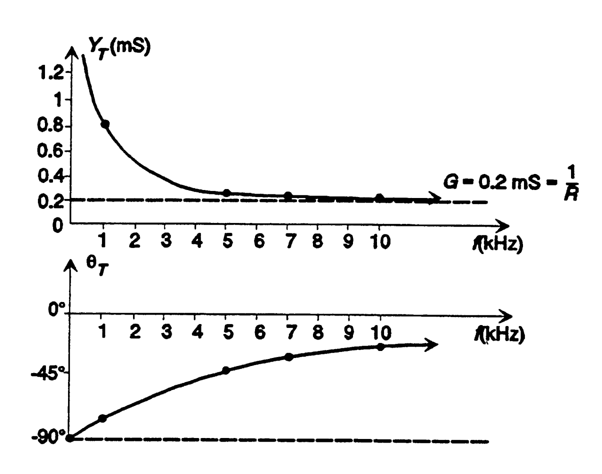


c. $I_R = \dfrac{E}{R} = \dfrac{40\text{ V}}{5\text{ k}\Omega} = 8\text{ mA (constant)}$



37. $Y_T = \dfrac{1}{Z_T}$ (use data of Prob. 35), $\theta_{T_Y} = -\theta_{T_Z}$

f	Y_T	θ_T
0 Hz	∞	−90.0°
1 kHz	0.82 mS	−75.86°
5 kHz	0.256 mS	−38.53°
7 kHz	0.23 mS	−29.6°
10 kHz	0.215 mS	−21.69°



39. a. $R_p = \dfrac{R_s^2 + X_s^2}{R_s} = \dfrac{(22\ \Omega)^2 + (40\ \Omega)^2}{22\ \Omega} = \mathbf{94.73\ \Omega}\ (R)$

$X_p = \dfrac{R_s^2 + X_s^2}{X_s} = \dfrac{2084\ \Omega}{40} = \mathbf{52.1\ \Omega}\ (C)$

b. $R_p = \dfrac{R_s^2 + X_s^2}{R_s} = \dfrac{(2\ k\Omega)^2 + (2\ k\Omega)^2}{2\ k\Omega} = \mathbf{4\ k\Omega}\ (R)$

$X_p = \dfrac{R_s^2 + X_s^2}{X_s} = \dfrac{(2\ k\Omega)^2 + (2\ k\Omega)^2}{2\ k\Omega} = \mathbf{4\ k\Omega}\ (C)$

41. a. $C_T = 2\ \mu F$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi(10^3\ Hz)(2\ \mu F)} = 79.62\ \Omega$

$X_L = \omega L = 2\pi(10^3\ Hz)(10\ mH) = 62.80\ \Omega$

$\mathbf{Y}_T = \dfrac{1}{220\ \Omega\ \angle 0°} + \dfrac{1}{79.62\ \Omega\ \angle -90°} + \dfrac{1}{62.8\ \Omega\ \angle 90°}$

$= 4.55\ mS\ \angle 0° + 12.56\ mS\ \angle 90° + 15.92\ mS\ \angle -90°$

$= \mathbf{4.55\ mS - j3.36\ mS = 5.66\ mS\ \angle -36.44°}$

$\mathbf{E} = \mathbf{I}/\mathbf{Y}_T = 1\ A\ \angle 0°/5.66\ mS\ \angle -36.44° = \mathbf{176.68\ V\ \angle 36.44°}$

$\mathbf{I}_R = \dfrac{E\ \angle\theta}{R\ \angle 0°} = 176.68\ V\ \angle 36.44°/220\ \Omega\ \angle 0° = \mathbf{0.803\ A\ \angle 36.44°}$

$\mathbf{I}_L = \dfrac{E\ \angle\theta}{X_L\ \angle 90°} = 176.68\ V\ \angle 36.44°/62.80\ \angle 90° = \mathbf{2.813\ A\ \angle -53.56°}$

b. $F_p = G/Y_T = 4.55\ mS/5.66\ mS = \mathbf{0.804}$ **lagging**

e. $P = I^2R = (0.803\ A)^2\ 220\ \Omega = \mathbf{141.86\ W}$

f. $\mathbf{I}_s = \mathbf{I}_R + 2\mathbf{I}_C + \mathbf{I}_L$

and $\mathbf{I}_C = \dfrac{\mathbf{I}_s - \mathbf{I}_R - \mathbf{I}_L}{2}$

$= \dfrac{1\text{ A }\angle 0° - 0.803\text{ A }\angle 36.44° - 2.813\text{ A }\angle -53.56°}{2}$

$= \dfrac{1 - (0.646 + j0.477) - (1.671 - j2.263)}{2} = \dfrac{-1.317 + j1.786}{2}$

$\mathbf{I}_C = -0.657 + j0.893 = \mathbf{1.11\text{ A }\angle 126.43°}$

g. $\mathbf{Z}_T = \dfrac{1}{\mathbf{Y}_T} = \dfrac{1}{5.66\text{ mS }\angle -36.44°} = 176.7\ \Omega\ \angle 36.44°$

$= \mathbf{142.15\ \Omega + j104.96\ \Omega} = R + jX_L$

43. $P = VI\cos\theta = 3000\text{ W}$

$\cos\theta = \dfrac{3000\text{ W}}{VI} = \dfrac{3000\text{ W}}{(100\text{ V})(40\text{ A})} = \dfrac{3000}{4000} = 0.75$ (lagging)

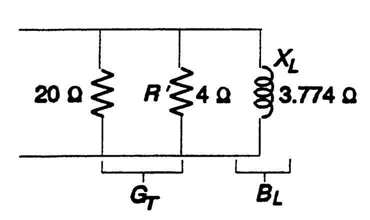
$\theta = \cos^{-1} 0.75 = 41.41°$

$\mathbf{Y}_T = \dfrac{\mathbf{I}}{\mathbf{E}} = \dfrac{40\text{ A }\angle -41.41°}{100\text{ V }\angle 0°} = 0.4\text{ S }\angle -41.41° = 0.3\text{ S} - j0.265\text{ S} = G_T - jB_L$

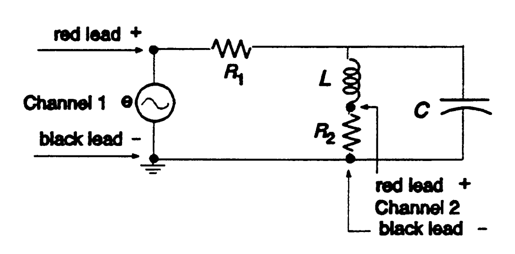
$G_T = 0.3\text{ S} = \dfrac{1}{20\ \Omega} + \dfrac{1}{R'} = 0.05\text{ S} + \dfrac{1}{R'}$

and $R' = \dfrac{1}{0.25\text{ S}} = \mathbf{4\ \Omega}$

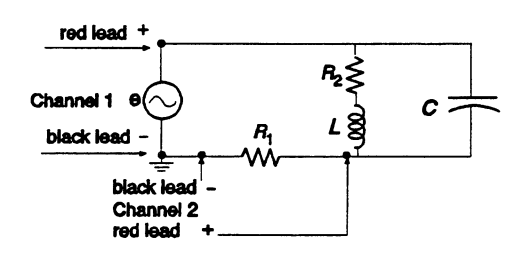
$X_L = \dfrac{1}{B_L} = \dfrac{1}{0.265\text{ S}} = \mathbf{3.744\ \Omega}$



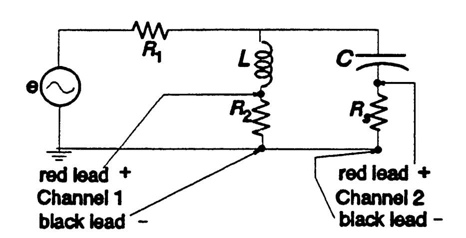
45. a. e and v_{R_2}



b. e and i_s



c. i_L and i_C


R1
L
C
e
R2
Rs
red lead +
Channel 1
black lead -
red lead +
Channel 2
black lead -

CHAPTER 15 (Even)

2. a. $\mathbf{V} = 14.847\text{ V} \angle 10°, \mathbf{I} = \dfrac{V \angle\theta}{R \angle 0°} = \dfrac{14.847\text{ V} \angle 10°}{3\ \Omega \angle 0°} = 4.949\text{ A} \angle 10°$

$i = \mathbf{7\ sin(\omega t + 10°)}$

b. $\mathbf{V} = 34.643\text{ V} \angle 70°, \mathbf{I} = \dfrac{V \angle\theta}{X_L \angle 90°} = \dfrac{34.643\text{ V} \angle 70°}{7\ \Omega \angle 90°} = 4.949\text{ A} \angle -20°$

$i = \mathbf{7\ sin(\omega t - 20°)}$

c. $\mathbf{V} = 17.675\text{ V} \angle -20°, \mathbf{I} = \dfrac{V \angle\theta}{X_C \angle -90°} = \dfrac{17.675\text{ V} \angle -20°}{100\ \Omega \angle -90°} = 0.1768\text{ A} \angle 70°$

$i = \mathbf{0.25\ sin(\omega t + 70°)}$

d. $\mathbf{V} = 2.828\text{ mV} \angle -120°, \mathbf{I} = \dfrac{V \angle\theta}{R \angle 0°} = \dfrac{2.828\text{ mV} \angle -120°}{5.1\text{ k}\Omega \angle 0°} = 0.555\ \mu\text{A} \angle -120°$

$i = \mathbf{0.785 \times 10^{-6}\ sin(\omega t - 120°)}$

e. $\mathbf{V} = 11.312\text{ V} \angle 60°, \mathbf{I} = \dfrac{V \angle\theta}{X_L \angle 90°} = \dfrac{11.312\text{ V} \angle 60°}{(377\text{ rad/s})(0.1\text{ H} \angle 90°} = 0.3\text{ A} \angle -30°$

$i = \mathbf{0.424\ sin(377t - 30°)}$

f. $\mathbf{V} = 84.84\text{ V} \angle 0°, X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(5\text{ k}\Omega)(2\ \mu\text{F})} = 15.924\ \Omega$

$\mathbf{I} = \dfrac{V \angle\theta}{X_C \angle -90°} = \dfrac{84.84\text{ V} \angle 0°}{15.924\ \Omega \angle -90°} = 5.328\text{ A} \angle 90°$

$i = \mathbf{7.534\ sin(\omega t + 90°)}$

4. a. $\mathbf{Z}_T = 6.8\ \Omega + j6.8\ \Omega = \mathbf{9.167\ \Omega \angle 45°}$

b. $\mathbf{Z}_T = 2\ \Omega - j6\ \Omega + 8\ \Omega = \mathbf{10\ \Omega - j6\ \Omega} = \mathbf{11.66\ \Omega \angle -30.96°}$

c. $\mathbf{Z}_T = 1\text{ k}\Omega + j3\text{ k}\Omega + 4\text{ k}\Omega + j7\text{ k}\Omega = \mathbf{5\text{ k}\Omega + j10\text{ k}\Omega} = \mathbf{11.18\text{ k}\Omega \angle 63.435°}$

6. a. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{120\text{ V} \angle 0°}{60\text{ A} \angle 70°} = 2\Omega \angle -70° = \mathbf{0.684\ \Omega - j1.879\ \Omega} = R - jX_C$

b. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{80\text{ V} \angle 320°}{20\text{ mA} \angle 40°} = 4\text{ k}\Omega \angle 280° = 4\text{ k}\Omega \angle -80° = \mathbf{0.695\text{ k}\Omega - j3.939\text{ k}\Omega}$

$= R - jX_C$

c. $\mathbf{Z}_T = \dfrac{\mathbf{E}}{\mathbf{I}} = \dfrac{8\text{ kV} \angle 0°}{0.2\text{ A} \angle -60°} = 40\text{ k}\Omega \angle 60° = \mathbf{20\text{ k}\Omega + j34.64\text{ k}\Omega} = R + jX_L$

8. a. $\mathbf{Z}_T = 10\ \Omega - j30\ \Omega = \mathbf{31.62\ \Omega \angle -71.57°}$

c. $\mathbf{I} = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{120\text{ V} \angle 20°}{31.62\ \Omega \angle -71.57°} = \mathbf{3.795\ A \angle 91.57°}$

$\mathbf{V}_R = (I \angle \theta)(R \angle 0°) = (3.795\text{ A} \angle 91.57°)(10\ \Omega \angle 0°) = \mathbf{37.95\ V \angle 91.57°}$
$\mathbf{V}_C = (I \angle \theta)(X_C \angle -90°) = (3.795\text{ A} \angle 91.57°)(30\ \Omega \angle -90°) = \mathbf{113.85\ V \angle 1.57°}$

f. $P = I^2R = (3.795\text{ A})^2\ 10\ \Omega = \mathbf{144.02\ W}$

g. $F_p = R/Z_T = 10\ \Omega/31.62\ \Omega =$ **0.316 leading**

h. $i = \mathbf{5.37 \sin(377t + 91.57°)}$
$v_R = \mathbf{53.66 \sin(377t + 91.57°)}$
$v_C = \mathbf{160.98 \sin(377t + 1.57°)}$

10. a. $\mathbf{Z}_T = 2\ \Omega + j6\ \Omega - j10\ \Omega = 2\ \Omega - j4\ \Omega = \mathbf{4.47\ \Omega \angle -63.43°}$

c. $X_L = \omega L \Rightarrow L = \dfrac{X_L}{\omega} = \dfrac{6\ \Omega}{377\text{ rad/s}} = \mathbf{16\ mH}$
$X_C = \dfrac{1}{\omega C} \Rightarrow C = \dfrac{1}{\omega X_C} = \dfrac{1}{(377\text{ rad/s})(10\ \Omega)} = \mathbf{265\ \mu F}$

d. $\mathbf{I} = \dfrac{\mathbf{E}}{\mathbf{Z}_T} = \dfrac{50\text{ V} \angle 0°}{4.47\ \Omega \angle -63.43°} = \mathbf{11.19\ A \angle 63.43°}$
$\mathbf{V}_R = (I \angle \theta)(R \angle 0°) = (11.19\text{ A} \angle 63.43°)(2\ \Omega \angle 0°) = \mathbf{22.38\ V \angle 63.43°}$
$\mathbf{V}_L = (I \angle \theta)(X_L \angle 90°) = (11.19\text{ A} \angle 63.43°)(6\ \Omega \angle 90°) = \mathbf{67.14\ V \angle 153.43°}$
$\mathbf{V}_C = (I \angle \theta)(X_C \angle -90°) = (11.19\text{ A} \angle 63.43°)(10\ \Omega \angle -90°) = \mathbf{111.9\ V \angle -26.57°}$

f. $\mathbf{E} = \mathbf{V}_R + \mathbf{V}_L + \mathbf{V}_C$
$50\text{ V} \angle 0° = 22.38\text{ V} \angle 63.43° + 67.14\text{ V} \angle 153.43° + 111.9\text{ V} \angle -26.57°$
$= (10 + j20) + (-60 + j30) + (100 - j50)$
$50\text{ V} \angle 0° \stackrel{\checkmark}{=} 50\text{ V} \angle 0°$

g. $P = I^2R = (11.19\text{ A})^2\ 2\ \Omega = \mathbf{250.43\ W}$

h. $F_p = \cos\theta_T = \dfrac{R}{Z_T} = 2\ \Omega/4.47\ \Omega =$ **0.447 leading**

i. $i = \mathbf{15.82 \sin(377t + 63.43°)}$
$e = \mathbf{70.7 \sin 377t}$
$v_R = \mathbf{31.65 \sin(377t + 62.43°)}$
$v_L = \mathbf{94.94 \sin(377t + 153.43°)}$
$v_C = \mathbf{158.227 \sin(377t - 26.57°)}$

12. $V_{80\Omega}(\text{rms}) = 0.7071\left[\dfrac{45.27\text{ V}}{2}\right] = 16\text{ V}$
$V_{\text{scope}} = \dfrac{80\ \Omega\,(20\text{ V})}{80\ \Omega + R} = 16\text{ V}$
$1600 = 1280 + 16\,R$
$R = \dfrac{320}{16} = \mathbf{20\ \Omega}$

14. $V_R(\text{rms}) = 0.7071\left[\frac{8.27\text{ V}}{2}\right] = 2.924\text{ V}$

V_R 2.924 V, I, E 12 V, V_C

$$V_C = \sqrt{E^2 - V_R^2}$$
$$= \sqrt{144 - 8.55} = \sqrt{135.45} = 11.638\text{ V}$$

$$I_C = I_R = \frac{2.924\text{ V}}{10\text{ k}\Omega} = 292.4\ \mu\text{A}$$
$$X_C = \frac{V_C}{I_C} = \frac{11.638\text{ V}}{292.4\ \mu\text{A}} = 39.802\text{ k}\Omega$$
$$X_C = \frac{1}{2\pi fC} \Rightarrow C = \frac{1}{2\pi fX_C} = \frac{1}{2\pi(40\text{ kHz})(39.802\text{ k}\Omega)} = 99.967\text{ pF} \cong \mathbf{100\ pF}$$

16. a. $\mathbf{V}_1 = \dfrac{(20\ \Omega\ \angle 90°)(20\text{ V}\ \angle 70°)}{20\ \Omega + j20\ \Omega - j60\ \Omega} = \mathbf{8.94\ V\ \angle 223.43°}$

$\mathbf{V}_2 = \dfrac{(60\ \Omega\ \angle -90°)(20\text{ V}\ \angle 70°)}{44.72\ \Omega\ \angle -63.43°} = \mathbf{26.83\ V\ \angle 43.43°}$

b. $\mathbf{Z}_T = 4.7\text{ k}\Omega + j30\text{ k}\Omega + 3.3\text{ k}\Omega - j10\text{ k}\Omega = 8\text{ k}\Omega + j20\text{ k}\Omega = 21.541\text{ k}\Omega\ \angle 68.199°$

$\mathbf{Z}'_T = 3.3\text{ k}\Omega + j30\text{ k}\Omega - j10\text{ k}\Omega = 3.3\text{ k}\Omega + j20\text{ k}\Omega = 20.27\text{ k}\Omega\ \angle 80.631°$

$\mathbf{V}_1 = \dfrac{\mathbf{Z}'_T\mathbf{E}}{\mathbf{Z}_T} = \dfrac{(20.27\text{ k}\Omega\ \angle 80.631°)(120\text{ V}\ \angle 0°)}{21.541\text{ k}\Omega\ \angle 68.199°} = \mathbf{112.92\ V\ \angle 12.432°}$

$\mathbf{V}_2 = \dfrac{\mathbf{Z}''_T\mathbf{E}}{\mathbf{Z}_T}$ $\quad \mathbf{Z}''_T = 3.3\text{ k}\Omega - j10\text{ k}\Omega = 10.53\text{ k}\Omega\ \angle -71.737°$

$= \dfrac{(10.53\text{ k}\Omega\ \angle -71.737°)(120\text{ V}\ \angle 0°)}{21.541\text{ k}\Omega\ \angle 68.199°} = \mathbf{58.66\ V\ \angle -139.936°}$

18. a. $X_L = \omega L = (377\text{ rad/s})(0.4\text{ H}) = 150.8\ \Omega$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{(377\text{ rad/s})(1 \times 10^{-3}\text{ F})} = 2.653\ \Omega$

$\mathbf{Z}_T = 30\ \Omega + j150.8\ \Omega - j2.653\ \Omega$

$= 30\ \Omega + j148.147\ \Omega = 151.154\ \Omega\ \angle 78.552°$

$\mathbf{I} = \mathbf{E}/\mathbf{Z}_T = 20\text{ V}\ \angle 40°/151.154\ \Omega\ \angle 78.552° = \mathbf{0.132\ A\ \angle -38.552°}$

$\mathbf{V}_R = (I\ \angle\theta)(R\ \angle 0°) = (0.132\text{ A}\ \angle -38.552°)(30\ \Omega\ \angle 0°) = \mathbf{3.96\ V\ \angle -38.552°}$

$\mathbf{V}_C = (I\ \angle\theta)(X_C\ \angle -90°) = (0.132\text{ A}\ \angle -38.552°)(2.653\ \Omega\ \angle -90°)$

$= \mathbf{0.35\ V\ \angle -128.552°}$

b. $F_p = \cos\theta_T = R/Z_T = 30\ \Omega/151.154\ \Omega = \mathbf{0.198\ lagging}$

c. $P = I^2R = (0.132\text{ A})^2\ 30\ \Omega = \mathbf{0.523\ W}$

f. $\mathbf{V}_R = \dfrac{(30\ \Omega\ \angle 0°)(20\text{ V}\ \angle 40°)}{151.154\ \Omega\ \angle 78.552°} = \mathbf{3.969\ V\ \angle -38.552°}$

$\mathbf{V}_C = \dfrac{(2.653\ \Omega\ \angle -90°)(20\text{ V}\ \angle 40°)}{151.154\ \Omega\ \angle 78.552°} = \mathbf{0.351\ V\ \angle 128.552°}$

g. $\mathbf{Z}_T = 30\ \Omega + j148.147\ \Omega = R + jX_L$

20. $P = VI\cos\theta \Rightarrow 300\text{ W} = (120\text{ V})(3\text{ A})\cos\theta$

$$\cos\theta = 0.833 \Rightarrow \theta = \mathbf{33.59°}$$

$$\mathbf{V} = 120\text{ V}\ \angle 0°, \mathbf{I} = 3\text{ A}\ \angle -33.59°$$

$$\mathbf{Z}_T = \frac{\mathbf{V}}{\mathbf{I}} = \frac{120\text{ V}\ \angle 0°}{3\text{ A}\ \angle -33.59°} = 40\ \Omega\ \angle 33.59° = \mathbf{33.34\ \Omega + j22.10\ \Omega}$$

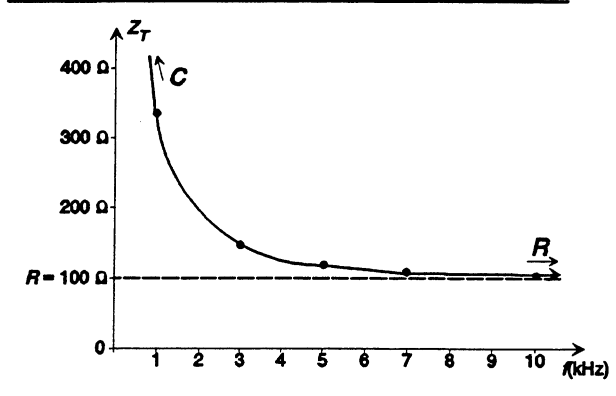
$$R_T = 33.34\ \Omega = 2\ \Omega + R \Rightarrow R = 31.34\ \Omega$$

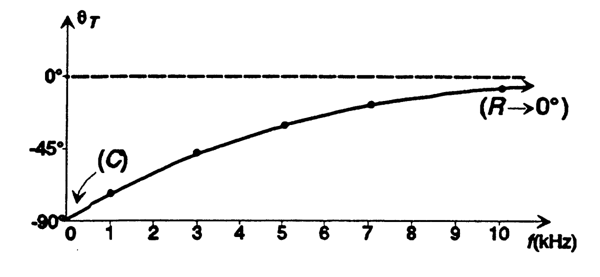
$\mathbf{Z}_T$: 2 Ω, 31.34 Ω, 22.10 Ω

22. a. $\mathbf{Z}_T = \sqrt{R^2 + X_C^2}\ \angle -\tan^{-1}X_C/R$

$$|Z_T| = \sqrt{R^2 + X_C^2},\ \theta_T = -\tan^{-1}X_C/R$$

f	$\|Z_T\|$	θ_T
0 kHz	∞ Ω	−90.0°
1 kHz	333.64 Ω	−72.56°
3 kHz	145.8 Ω	−46.7°
5 kHz	118.54 Ω	−32.48°
7 kHz	109.85 Ω	−24.45°
10 kHz	104.94 Ω	−17.66°

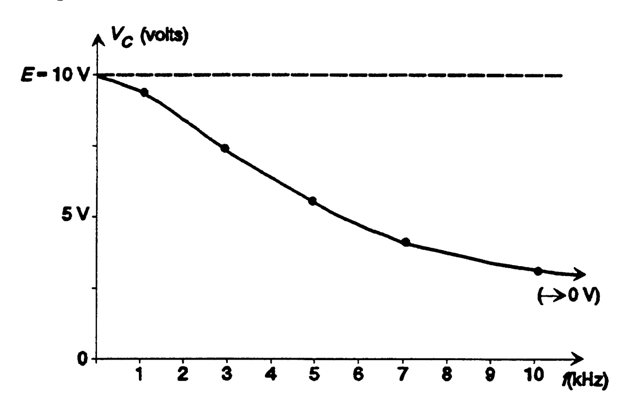




b. $\mathbf{V}_C = \dfrac{(X_C \angle -90°)(E \angle 0°)}{R - jX_C} = \dfrac{X_C E}{\sqrt{R^2 + X_C^2}} \angle -90° + \tan^{-1} X_C/R$

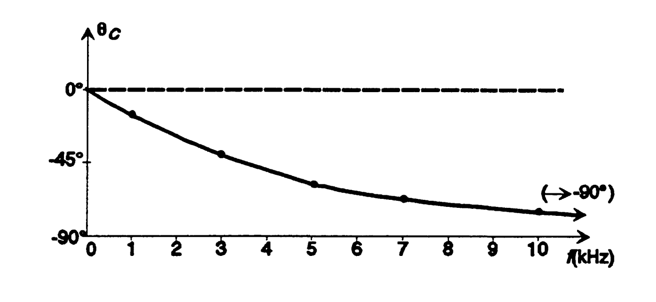
$|V_C| = \dfrac{X_C E}{\sqrt{R^2 + X_C^2}}$

f	$\lvert V_C \rvert$
0 Hz	10.0 V
1 kHz	9.54 V
3 kHz	7.28 V
5 kHz	5.37 V
7 kHz	4.14 V
10 kHz	3.03 V



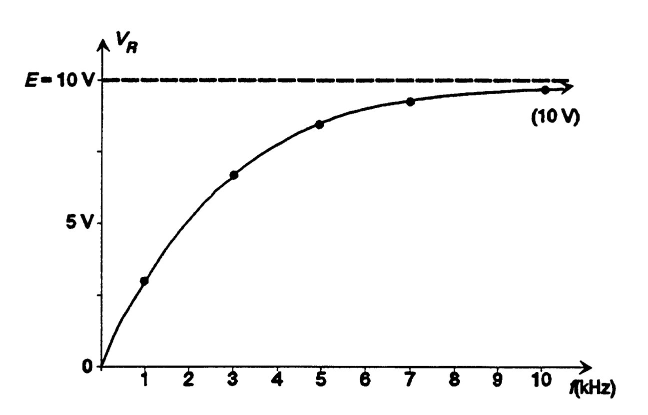
c. $\theta_C = -90° + \tan^{-1} X_C/R$

f	θ_C
0 Hz	0.0°
1 kHz	−17.44°
3 kHz	−43.3°
5 kHz	−57.52°
7 kHz	−65.55°
10 kHz	−72.34°



d. $|V_R| = \dfrac{RE}{\sqrt{R^2 + X_C^2}}$

f	$\lvert V_R \rvert$
0 Hz	0.0 V
1 kHz	3.0 V
3 kHz	6.86 V
5 kHz	8.44 V
7 kHz	9.10 V
10 kHz	9.53 V



24. a. $\mathbf{Z}_T = \mathbf{47\ \Omega \angle 0°} = R \angle 0°, \mathbf{Y}_T = \mathbf{0.021\ S \angle 0°} = G \angle 0°$

b. $\mathbf{Z}_T = \mathbf{200\ \Omega \angle 90°} = X_L \angle 90°, \mathbf{Y}_T = \mathbf{5 \times 10^{-3}\ S \angle -90°} = B_L \angle -90°$

c. $\mathbf{Z}_T = \mathbf{0.6\ \Omega \angle -90°} = X_C \angle -90°, \mathbf{Y}_T = \mathbf{1.667\ S \angle 90°} = B_C \angle 90°$

d. $\mathbf{Z}_T = \dfrac{(10\ \Omega \angle 0°)(60\ \Omega \angle 90°)}{10\ \Omega + j60\ \Omega} = \mathbf{9.86\ \Omega \angle 9.46°} = \mathbf{9.726\ \Omega + j1.621\ \Omega} = R + jX_L$

$\mathbf{Y}_T = \mathbf{0.1014\ S\ \angle -9.46° = 0.1\ S} - \boldsymbol{j}\mathbf{0.0167\ S} = G - jB_L$

e. $\mathbf{Z}_T = \dfrac{(11\ \Omega \angle 0°)(6\ \Omega\ \angle -90°)}{11\ \Omega - j6\ \Omega} = \dfrac{66\ \Omega\ \angle -90°}{12.53\ \Omega\ \angle -28.61°} = \mathbf{5.267\ \Omega\ \angle -61.39°}$

$= \mathbf{2.522\ \Omega} - \boldsymbol{j}\mathbf{4.624\ \Omega} = R - jX_C$

$\mathbf{Y}_T = \mathbf{0.190\ S\ \angle 61.39° = 0.091} + \boldsymbol{j}\mathbf{0.167\ S} = G + jB_C$

f. $\mathbf{Y}_T = \dfrac{1}{3\ \text{k}\Omega\ \angle 0°} + \dfrac{1}{6\ \text{k}\Omega\ \angle 90°} + \dfrac{1}{9\ \text{k}\Omega\ \angle -90°}$

$= 0.333 \times 10^{-3}\ \angle 0° + 0.167 \times 10^{-3}\ \angle -90° + 0.111 \times 10^{-3}\ \angle 90°$

$= \mathbf{0.333 \times 10^{-3}\ S} - \boldsymbol{j}\mathbf{0.056 \times 10^{-3}\ S = 0.338 \times 10^{-3}\ S\ \angle -9.546°}$

$= G - jB_L$

$\mathbf{Z}_T = \dfrac{1}{\mathbf{Y}_T} = \mathbf{2.959\ k\Omega\ \angle 9.546° = 2.918\ k\Omega} + \boldsymbol{j}\mathbf{0.491\ k\Omega}$

26. a. $\mathbf{Y}_T = \dfrac{\mathbf{I}}{\mathbf{E}} = \dfrac{60\ \text{A}\ \angle 70°}{120\ \text{V}\ \angle 0°} = 0.5\ \text{S}\ \angle 70° = 0.171 + j0.470 = G + jB_C$

$R = \dfrac{1}{G} = \mathbf{5.848\ \Omega},\ X_C = \dfrac{1}{B_C} = \mathbf{2.128\ \Omega}$

b. $\mathbf{Y}_T = \dfrac{\mathbf{I}}{\mathbf{E}} = \dfrac{20\ \text{mA}\ \angle 40°}{80\ \text{V}\ \angle 320°} = 0.25\ \text{mS}\ \angle -280° = 0.25\ \text{mS}\ \angle 80°$

$= 0.043\ \text{mS} + j0.246\ \text{mS} = G + jB_C$

$R = \dfrac{1}{G} = \mathbf{23.26\ k\Omega},\ X_C = \dfrac{1}{B_C} = \mathbf{4.065\ k\Omega}$

c. $\mathbf{Y}_T = \dfrac{\mathbf{I}}{\mathbf{E}} = \dfrac{0.2\ \text{A}\ \angle -60°}{8\ \text{kV}\ \angle 0°} = 0.25\ \text{mS}\ \angle -60° = 0.0125\ \text{mS} - j0.02165 = G - jB_L$

$R = \dfrac{1}{G} = \mathbf{80\ k\Omega},\ X_L = \dfrac{1}{B_L} = \mathbf{46.19\ k\Omega}$

28. a. $\mathbf{Y}_T = \dfrac{1}{10\ \text{k}\Omega\ \angle 0°} + \dfrac{1}{20\ \text{k}\Omega\ \angle -90°} = 0.1\ \text{mS}\ \angle 0° + 0.05\ \text{mS}\ \angle -90°$

$= \mathbf{0.112\ mS\ \angle 26.57°}$

c. $\mathbf{E} = \dfrac{\mathbf{I}_s}{\mathbf{Y}_T} = \dfrac{2\ \text{mA}\ \angle 20°}{0.1118\ \text{mS}\ \angle 26.565°} = \mathbf{17.89\ V\ \angle -6.565°}$

$\mathbf{I}_R = \dfrac{\mathbf{E}}{\mathbf{Z}_R} = \dfrac{17.89\ \text{V}\ \angle -6.565°}{10\ \text{k}\Omega\ \angle 0°} = \mathbf{1.789\ mA\ \angle -6.565°}$

$\mathbf{I}_C = \dfrac{\mathbf{E}}{\mathbf{Z}_C} = \dfrac{17.89\ \text{V}\ \angle -6.565°}{20\ \text{k}\Omega\ \angle -90°} = \mathbf{0.895\ mA\ \angle 83.435°}$

e. $\mathbf{I}_s = \mathbf{I}_R + \mathbf{I}_C$

$2\ \text{mA}\ \angle 20° = 1.789\ \text{mA}\ \angle -6.565° + 0.895\ \text{mA}\ \angle 83.435°$

$= (1.774\ \text{mA} - j0.204\ \text{mA}) + (0.102\ \text{mA} + j0.0887\ \text{mA})$

$= 1.876\ \text{mA} + j0.683\ \text{mA}$

$2\ \text{mA}\ \angle 20° \overset{\checkmark}{=} 2\ \text{mA}\ \angle 20°$

f. $P = I^2R = (1.789\ \text{mA})^2\ 10\ \text{k}\Omega = \mathbf{32\ mW}$

g. $F_p = \frac{G}{Y_T} = \frac{0.1 \text{ mS}}{0.1118 \text{ mS}} = \mathbf{0.894 \text{ leading}}$

h. $\omega = 2\pi f = 377$ rad/s

$i_s = \mathbf{2.828 \times 10^{-3} \sin(\omega t + 20°)}$

$i_R = \mathbf{2.53 \times 10^{-3} \sin(\omega t - 6.565°)}$

$i_C = \mathbf{1.266 \times 10^{-3} \sin(\omega t + 83.435°)}$

$e = \mathbf{25.3 \sin(\omega t - 6.565°)}$

30. a. $\mathbf{Y}_T = \frac{1}{1.2\ \Omega \angle 0°} + \frac{1}{2\ \Omega \angle 90°} + \frac{1}{5\ \Omega \angle -90°}$

$= 0.833 \text{ S} \angle 0° + 0.5 \text{ S} \angle -90° + 0.2 \text{ S} \angle 90°$

$= 0.833 \text{ S} - j0.3 \text{ S} = \mathbf{0.885 \text{ S} \angle -19.81°}$

b. $X_C = \frac{1}{\omega_C} \Rightarrow C = \frac{1}{\omega X_C} = \frac{1}{(377 \text{ rad/s})(5\ \Omega)} = \mathbf{531\ \mu F}$

$X_L = \omega L \Rightarrow L = \frac{X_L}{\omega} = \frac{2\ \Omega}{377 \text{ rad/s}} = \mathbf{5.31 \text{ mH}}$

d. $\mathbf{E} = \frac{\mathbf{I}_s}{\mathbf{Y}_T} = \frac{(0.707)(3 \text{ A}) \angle 60°}{0.885 \text{ S} \angle -19.81°} = \frac{2.121 \text{ A} \angle 60°}{0.885 \text{ S} \angle -19.81°} = \mathbf{2.397 \text{ V} \angle 79.81°}$

$\mathbf{I}_R = \frac{E \angle \theta}{R \angle 0°} = \frac{2.397 \text{ V} \angle 79.81°}{1.2\ \Omega \angle 0°} = \mathbf{1.998 \text{ A} \angle 79.81°}$

$\mathbf{I}_L = \frac{E \angle \theta}{X_L \angle 90°} = \frac{2.397 \text{ V} \angle 79.81°}{2\ \Omega \angle 90°} = \mathbf{1.199 \text{ A} \angle -10.19°}$

$\mathbf{I}_C = \frac{E \angle \theta}{X_C \angle -90°} = \frac{2.397 \text{ V} \angle 79.81°}{5\ \Omega \angle -90°} = \mathbf{0.479 \text{ A} \angle 169.81°}$

f. $\mathbf{I}_s = \mathbf{I}_R + \mathbf{I}_L + \mathbf{I}_C$

$2.121 \text{ A} \angle 60° = 1.998 \text{ A} \angle 79.81° + 1.199 \text{ A} \angle -10.19° + 0.479 \text{ A} \angle 169.81°$

$= (0.353 + j1.966) + (1.18 - j0.212) + (-0.471 + j0.086)$

$2.121 \text{ A} \angle 60° \stackrel{\checkmark}{=} 1.062 + j1.84 = 2.124 \angle 60°$

g. $P = I^2 R = (1.998 \text{ A})^2\ 1.2\ \Omega = \mathbf{4.79 \text{ W}}$

h. $F_p = \frac{G}{Y_T} = \frac{0.833 \text{ S}}{0.885 \text{ S}} = \mathbf{0.941 \text{ lagging}}$

i. $e = \mathbf{1.975 \sin(377t + 79.81°)}$

$i_R = \mathbf{2.825 \sin(377t + 79.81°)}$

$i_L = \mathbf{1.695 \sin(377t - 10.19°)}$

$i_C = \mathbf{0.677 \sin(377t + 169.81°)}$

32. a. $\mathbf{Y}_T = \frac{1}{5\Omega \angle -90°} + \frac{1}{22\Omega \angle 0°} + \frac{1}{10\ \Omega \angle 90°}$

$= 0.2 \text{ S} \angle 90° + 0.045 \text{ S} \angle 0° + 0.1 \text{ S} \angle -90°$

$= 0.045 \text{ S} + j0.1 \text{ S} = \mathbf{0.110 \text{ S} \angle 65.77°}$

c. $C = \frac{1}{\omega X_C} = \frac{1}{(377 \text{ rad/s})(5\ \Omega)} = \mathbf{636.9\ \mu F}$

$$L = \frac{X_L}{\omega} = \frac{10\ \Omega}{314\ \text{rad/s}} = \mathbf{31.8\ mH}$$

d. $\mathbf{E} = (0.707)(35.4\text{ V})\ \angle 60° = \mathbf{25.03\ V\ \angle 60°}$

$\mathbf{I}_s = \mathbf{E}\mathbf{Y}_T = (25.03\text{ V}\ \angle 60°)(0.11\text{ S}\ \angle 65.77°) = \mathbf{2.75\ A\ \angle 125.77°}$

$$\mathbf{I}_C = \frac{E\ \angle\theta}{X_C\ \angle -90°} = \frac{25.03\text{ V}\ \angle 60°}{5\ \angle -90°} = \mathbf{5\ A\ \angle 150°}$$

$$\mathbf{I}_R = \frac{E\ \angle\theta}{R\ \angle 0°} = \frac{25.03\text{ V}\ \angle 60°}{22\ \Omega\ \angle 0°} = \mathbf{1.14\ A\ \angle 60°}$$

$$\mathbf{I}_L = \frac{E\ \angle\theta}{X_L\ \angle 90°} = \frac{25.03\text{ V}\ \angle 60°}{10\ \Omega\ \angle 90°} = \mathbf{2.503\ A\ \angle -30°}$$

f. $\mathbf{I}_s = \mathbf{I}_C + \mathbf{I}_R + \mathbf{I}_L$

$2.75\text{ A}\ \angle 125.77° = 5\text{ A}\ \angle 150° = 1.14\text{ A}\ \angle 60° + 2.503\text{ A}\ \angle -30°$

$= (-4.33 + j2.5) + (0.57 + j0.9) + (2.17 - j1.25)$

$= -1.59 + j2.24 = 2.75\ \angle 125.4°$

g. $P = I^2R = (1.14\text{ A})^2\ 22\ \Omega = \mathbf{28.59\ W}$

h. $$F_p = \frac{G}{Y_T} = \frac{0.045\text{ S}}{0.110\text{ S}} = \mathbf{0.4091\ leading}$$

i. $e = \mathbf{35.4\ sin(314}t\mathbf{ + 60°)}$

$i_s = \mathbf{3.89\ sin(314}t\mathbf{ + 125.77°)}$

$i_C = \mathbf{7.07\ sin(314}t\mathbf{ + 150°)}$

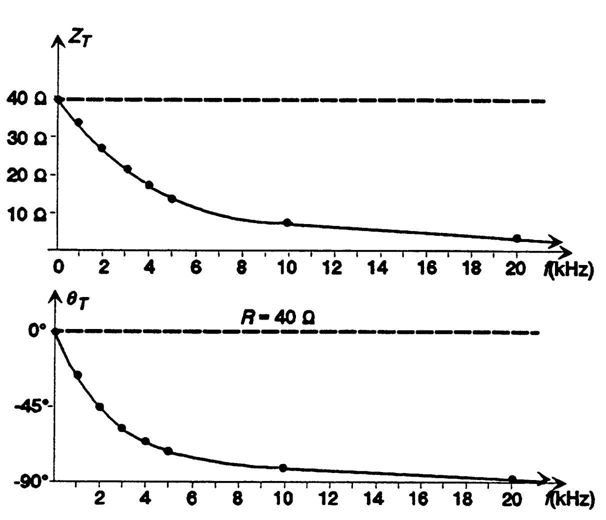
$i_R = \mathbf{1.61\ sin(314}t\mathbf{ + 60°)}$

$i_L = \mathbf{3.54\ sin(314}t\mathbf{ - 30°)}$

34. a. $$\mathbf{Z}_T = \frac{(R\ \angle 0°)(X_C\ \angle -90°)}{R - jX_C} = \frac{RX_C}{\sqrt{R^2 + X_C^2}}\ \angle -90° + \tan^{-1}X_C/R$$

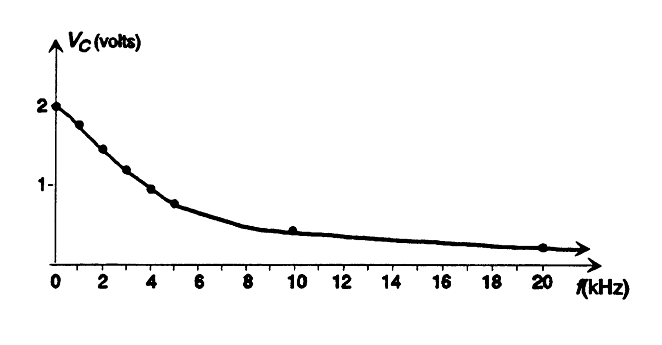
$$|Z_T| = \frac{RX_C}{\sqrt{R^2 + X_C^2}} \qquad \theta_T = -90° + \tan^{-1}X_C/R$$

f	$\lvert Z_T\rvert$	θ_T
0 Hz	40.0 Ω	0.0°
1 kHz	35.74 Ω	−26.67°
2 kHz	28.22 Ω	−45.14°
3 kHz	22.11 Ω	−56.44°
4 kHz	17.82 Ω	−63.55°
5 kHz	14.79 Ω	−68.30°
10 kHz	7.81 Ω	−78.75°
20 kHz	3.959 Ω	−89.86°



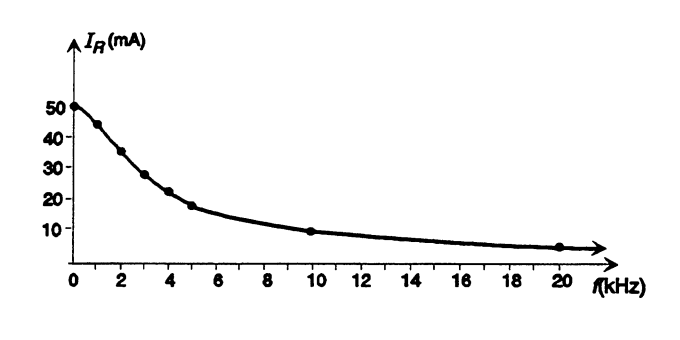
b. $|V_C| = \dfrac{IRX_C}{\sqrt{R^2 + X_C^2}} = I[Z_T(f)]$

f	$\lvert V_C \rvert$
0 kHz	2.0 V
1 kHz	1.787 V
2 kHz	1.411 V
3 kHz	1.105 V
4 kHz	0.891 V
5 kHz	0.740 V
10 kHz	0.391 V
20 kHz	0.198 V



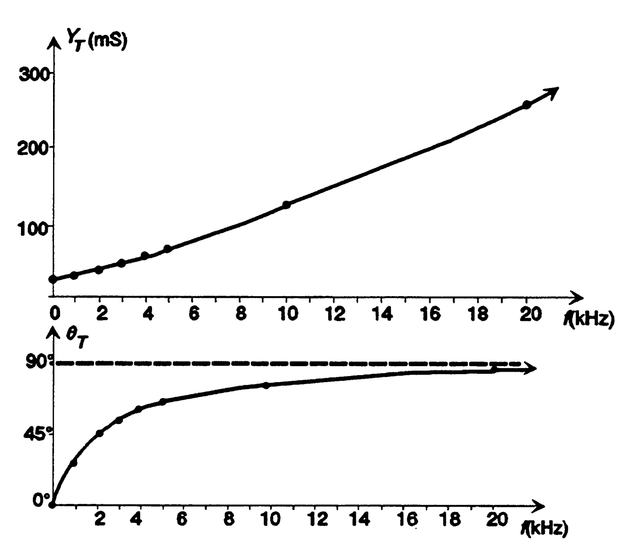
c. $|I_R| = \left|\dfrac{V_C}{R}\right|$

f	$\lvert I_R \rvert$
0 kHz	50.0 mA
1 kHz	44.7 mA
2 kHz	35.3 mA
3 kHz	27.64 mA
4 kHz	22.28 mA
5 kHz	18.50 mA
10 kHz	9.78 mA
20 kHz	4.95 mA



36. a. $\mathbf{Y}_T = \dfrac{\sqrt{R^2 + X_C^2}}{RX_C} \angle 90° - \tan^{-1} X_C/R$

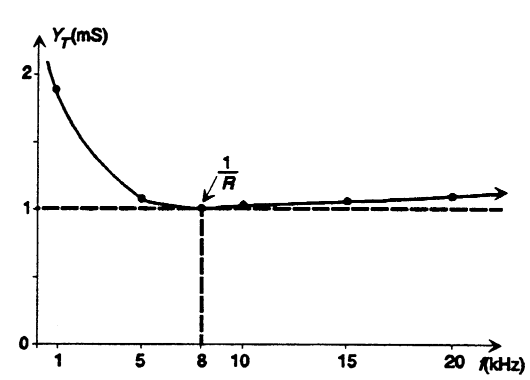
f	$\lvert Y_T \rvert$	θ_T
0 Hz	25.0 mS	0.0°
1 kHz	27.98 mS	26.67°
2 kHz	35.44 mS	45.14°
3 kHz	45.23 mS	56.44°
4 kHz	56.12 mS	63.55°
5 kHz	67.61 mS	68.30°
10 kHz	128.04 mS	78.75°
20 kHz	252.59 mS	89.86°



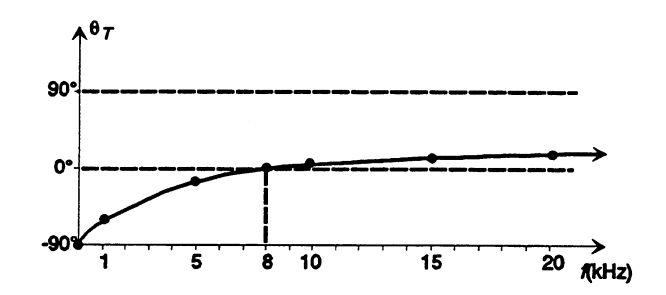
38. a. $\mathbf{Y}_T = G \angle 0° + B_L \angle -90° + B_C \angle 90°$

$$= \sqrt{G^2 + (B_C - B_L)^2} \angle \tan^{-1}\frac{B_C - B_L}{G}$$

f	$\lvert Y_T \rvert$
0 Hz	$X_L \Rightarrow 0\ \Omega$, $Z_T = 0\ \Omega$, $Y_T = \infty\ \Omega$
1 kHz	1.857 mS
5 kHz	1.018 mS
10 kHz	1.004 mS
15 kHz	1.036 mS
20 kHz	1.086 mS

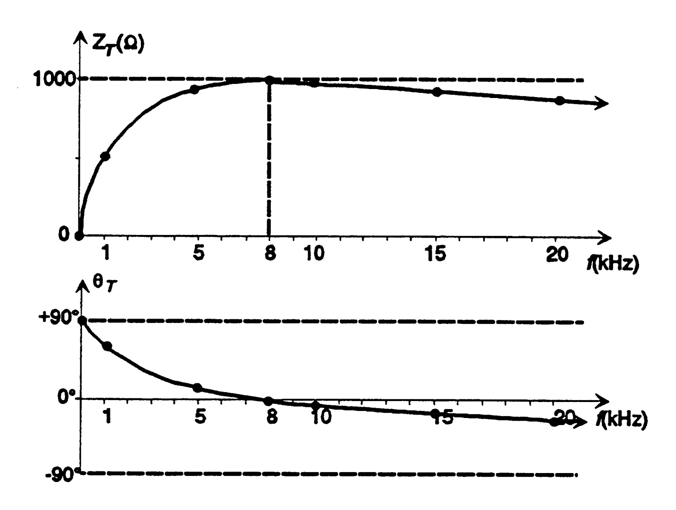


f	$\lvert \theta_T \rvert$
0 Hz	−90.0°
1 kHz	−57.42°
5 kHz	−10.87°
10 kHz	+5.26°
15 kHz	+15.16°
20 kHz	+22.95°



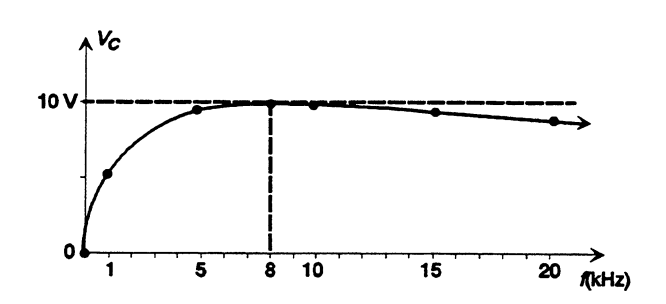
b. $Z_T = \dfrac{1}{Y_T}$, $\theta_{T_Z} = -\theta_{T_Y}$

f	Z_T	θ_T
0 kHz	0.0 Ω	90.0°
1 kHz	538.5 Ω	57.42°
5 kHz	982.32 Ω	10.87°
10 kHz	996.02 Ω	−5.26°
15 kHz	965.25 Ω	−15.16°
20 kHz	921.66 Ω	−22.95°



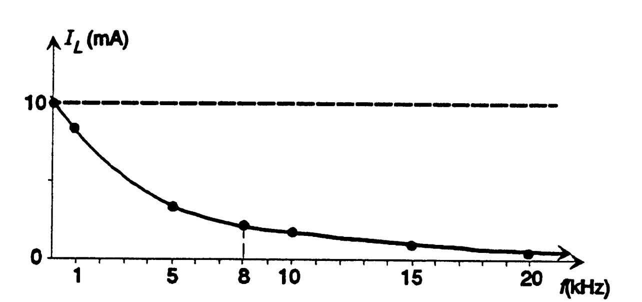
c. $V_C(f) = I[Z_T(f)]$

f	$\lvert V_C \rvert$
0 kHz	0.0 V
1 kHz	5.39 V
5 kHz	9.82 V
10 kHz	9.96 V
15 kHz	9.65 V
20 kHz	9.22 V



d. $I_L = \dfrac{V_C(f)}{X_L}$

f	I_L
0 kHz	10.0 mA
1 kHz	8.57 mA
5 kHz	3.13 mA
10 kHz	1.59 mA
15 kHz	1.02 mA
20 kHz	0.733 mA



40. a. $R_s = \dfrac{R_p X_p^2}{X_p^2 + R_p^2} = \dfrac{(4.7\text{ k}\Omega)(20\text{ k}\Omega)^2}{(20\text{ k}\Omega)^2 + (4.7\text{ k}\Omega)^2} = \dfrac{1880\text{ k}\Omega}{422.09} = \mathbf{4.454\text{ k}\Omega}$

$X_s = \dfrac{R_p^2 X_p}{X_p^2 + R_p^2} = \dfrac{(4.7\text{ k}\Omega)^2(20\text{ k}\Omega)}{422.09\text{ k}\Omega} = \dfrac{441.8\text{ k}\Omega}{422.09} = \mathbf{1.047\text{ k}\Omega}$

$\mathbf{Z}_T = \mathbf{4.454\text{ k}\Omega - j1.047\text{ k}\Omega}$

b. $R_s = \dfrac{R_p X_p^2}{X_p^2 + R_p^2} = \dfrac{(68\ \Omega)(40\ \Omega)^2}{(40\ \Omega)^2 + (68\ \Omega)^2} = \mathbf{17.481\ \Omega}$

$X_s = \dfrac{R_p^2 X_p}{X_p^2 + R_p^2} = \dfrac{(68\ \Omega)^2(40\ \Omega)}{6224\ \Omega^2} = \mathbf{29.717\ \Omega}$

$\mathbf{Z}_T = \mathbf{17.481\ \Omega + j29.717\ \Omega}$

42. a. $(R = 220\ \Omega) \| (L = 1\text{ H}) \| (C = 2\ \mu\text{F})$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi(10^3\text{ Hz})(2\ \mu\text{F})} = 79.62\ \Omega$

$X_L = \omega L = 2\pi(10^3\text{ Hz})(1\text{ H}) = 6.28\text{ k}\Omega$

$\mathbf{Y}_T = \dfrac{1}{220\ \Omega\ \angle 0°} + \dfrac{1}{6.28 \times 10^3\ \Omega\ \angle 90°} + \dfrac{1}{79.62\ \Omega\ \angle -90°}$
$= 0.0045 - j0.1592 \times 10^{-3} + j0.0126$
$= 4.5 \times 10^{-3} - j0.1592 \times 10^{-3} + j12.6 \times 10^{-3}$
$= \mathbf{4.5\text{ mS} + j12.44\text{ mS} = 13.23\text{ mS}\ \angle 70.11°}$

$\mathbf{E} = \mathbf{I}/\mathbf{Y}_T = 1\text{ A}\ \angle 0°/13.23\text{ mS}\ \angle 70.11° = \mathbf{75.6\text{ V}\ \angle -70.11°}$

$\mathbf{I}_R = \dfrac{E\ \angle\theta}{R\ \angle 0°} = 75.6\text{ V}\ \angle -70.11°/220\ \Omega\ \angle 0° = \mathbf{0.3436\text{ A}\ \angle -70.11°}$

$\mathbf{I}_L = \dfrac{E\ \angle\theta}{X_L\ \angle 90°} = 75.6\text{ V}\ \angle -70.11°/6.28\text{ k}\Omega\ \angle 90° = \mathbf{12.04\text{ mA}\ \angle -160.11°}$

b. $F_p = \dfrac{G}{Y_T} = \dfrac{4.5\text{ mS}}{13.23\text{ mS}} = \mathbf{0.3401\text{ leading}}$

c. $P = I^2R = (0.3436\text{A})^2\ 220\ \Omega = \mathbf{25.973\text{ W}}$

f. $2\mathbf{I}_C = \mathbf{I}_s - \mathbf{I}_R - \mathbf{I}_L$

$$\mathbf{I}_C = \frac{\mathbf{I}_s - \mathbf{I}_R - \mathbf{I}_L}{2} = \frac{1\text{ A}\angle 0^\circ - 0.3436\text{ A}\angle -70.11^\circ - 12.04\text{ mA}\angle -160.11^\circ}{2}$$

$$= \frac{1 - (0.1169 - j0.3231) - (-11.322\times 10^{-3} - j4.0962\times 10^{-3})}{2}$$

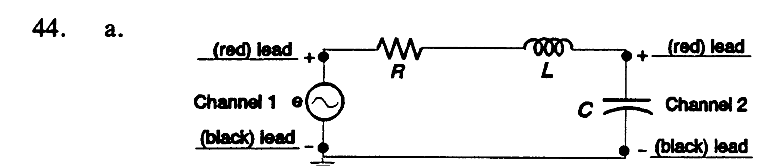
$$= \frac{0.8944 + j0.319}{2}$$

$\mathbf{I}_C = 0.4472 + j0.1595 = \mathbf{0.4748\text{ A}\angle 19.63^\circ}$

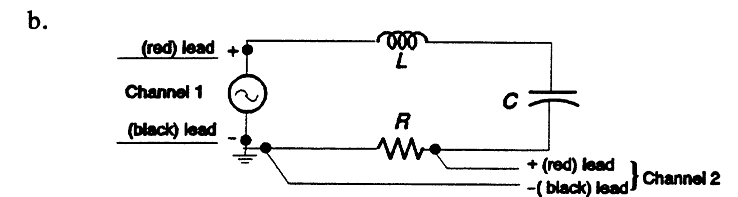
g. $\mathbf{Z}_T = \dfrac{1}{\mathbf{Y}_T} = \dfrac{1}{13.23\text{ mS}\angle 70.11^\circ} = 75.59\ \Omega\angle -70.11^\circ = \mathbf{25.72 - j71.08}$

$\mathbf{R = 25.72\ \Omega,\ X_C = 71.08\ \Omega}$

44. a.



b.



c.

(red) lead — R — C — (red) lead; Channel 1; L; Channel 2; (black) lead — (black) lead

46. (I): (a) $\theta_{\text{div.}} = 0.8\text{ div.},\ \theta_T = 4\text{ div.}$

$$\theta = \frac{0.8\text{ div.}}{4\text{ div.}}\times 360^\circ = 72^\circ$$

$\mathbf{v_1}$ **leads** $\mathbf{v_2}$ **by 72°**

(b) v_1: peak-to-peak $= (5\text{ div.})(0.5\text{ V/div.}) = 2.5\text{ V}$

$$V_1(\text{rms}) = 0.7071\left[\frac{2.5\text{ V}}{2}\right] = \mathbf{0.884\text{ V}}$$

v_2: peak-to-peak $= (2.4\text{ div.})(0.5\text{ V/div.}) = 1.2\text{ V}$

$$V_2(\text{rms}) = 0.7071\left[\frac{1.2\text{ V}}{2}\right] = \mathbf{0.424\text{ V}}$$

(c) $T = (4\text{ div.})(0.2\text{ ms/div.}) = 0.8\text{ ms}$

$$f = \frac{1}{T} = \frac{1}{0.8\text{ ms}} = \mathbf{1.25\text{ kHz}}\text{ (both)}$$

(II): (a) $\theta_{div.} = 2.2$ div., $\theta_T = 6$ div.

$$\theta = \frac{2.2 \text{ div.}}{6 \text{ div.}} \times 360° = 132°$$

v_1 leads v_2 by 132°

(b) v_1: peak-to-peak = (2.8 div.)(2 V/div.) = 5.6 V

$$V_1(\text{rms}) = 0.7071\left[\frac{5.6 \text{ V}}{2}\right] = \mathbf{1.98\ V}$$

v_2: peak-to-peak = (4 div.)(2 V/div.) = 8 V

$$V_2(\text{rms}) = 0.7071\left[\frac{8 \text{ V}}{2}\right] = \mathbf{2.828\ V}$$

(c) $T = (6 \text{ div.})(10 \text{ ms/div.}) = 60\ \mu s$

$$f = \frac{1}{T} = \frac{1}{60\ \mu s} = \mathbf{16.67\ kHz}$$